Project Category: Forest Ecosystems

Project Title: Creating a Soil Vulnerability Index to identify drought sensitive areas

Project Leader or Principal Investigator responsible for completion of project: Dominique Bachelet, Conservation Biology Institute, dominique@consbio.org, 360-870-5782

Cooperators/Partners and anticipated project contributions: Wendy Peterman, Conservation Biology Institute, wendy@consbio.org, 541-971-1203, GIS soil analysis, development of soil vulnerability map, data uploading

Project Summary: This project will develop a soil vulnerability index and map indicating where forest cover will be most affected by climate change. Using this map, we will develop a greater understanding of potential changes in soil moisture and temperature regimes under future climate conditions. We will evaluate how this information can be used to improve vegetation models across the landscape. We will compare the results of different modeling approaches to the soil vulnerability map, synthesize the state of knowledge and uncertainty, and introduce management implications for action.

Project Proposal:
Background and Need:

Climate change is an important factor leading to forest dieback and species migration as they relate to drought, water stress, early snow melt, reduced snow cover, pest outbreaks and fire risk (McKenzie et al. 2004, Mote et al. 2005, van Mantgem et al. 2009, Allen et al. 2010). In the North Pacific landscape, precipitation as rainfall is projected to increase in winter and spring, and decrease in summer, while temperatures rise from 2 to 5^{o} C by 2080 (Mote and Salathe, 2010). Current models suggest that forest cover may increase briefly at high elevation in response to wetter winters, and dramatically decrease at lower elevation due to severe competition for water from shrubs and grasses (CIG, 2011). Others, however, suggest that there may be a vegetation shift to lower elevations due to a more favorable water balance (Crimmins et al, 2011). In order to reconcile these differing views, we will examine the soil characteristics that govern the reception, storage, and redistribution of precipitation, which in turn determine the supply of plant-available water seasonally and spatially. A closer examination of soil characteristics can give scientists and managers the tools they need to predict where trees will be most vulnerable to water stress in changing climates.

Drought stress can affect forests indirectly by increasing their vulnerability to pests and pathogens. Since 1984, the Oregon Coast Range has seen a dramatic increase in the Swiss Needle Cast. Black et al. (2010) showed that warmer temperatures in March through August are connected to decreased Douglas fir growth due to infestations of this fungus. Littell et al. (2009) projected a reduction of climate suitability for Douglas fir in the Puget Trough as well as increases in wildfires and mountain pine beetle outbreaks, which would affect tree growth and survival in the region. Lodgepole pines in British Columbia, Oregon, Washington and California have shown increased vulnerability to climate change in recent decades and been subject to well-documented beetle attacks (e.g. Coops and Waring 2010). Vegetation models indicate that lodgepole may disappear from most of its current range by the end of this century (Coops and Waring, 2011). Further North, Alaskan Yellow Cedar decline in southeast Alaska and portions of British Columbia has also been connected to changing air and soil temperatures (D'Amore and Hennon, 2006). Soil water availability is the key in all these systems to determine the drought stress level of trees and identify thresholds beyond which forest decline starts occurring.

The understanding of the soil response to changes in precipitation/snow cover and increasing temperatures is essential to predicting changes in both vegetation and animal communities in the coming decades, and salmonids are particularly at risk. Changes in precipitation and snowmelt are affecting stream flow seasonality and magnitude (Hamlet et al. 2007, Elsner et al. 2010). Rising air temperatures affect aquatic habitats directly by causing increases in stream temperatures and indirectly through nearby forest decline. Fish and other wildlife require forest cover for shade, bank stability, woody debris and nutrient inputs for stream health. Consequently any widespread tree mortality due to drought will affect wildlife survival and migration routes.

The over-arching issue of our work is climate change, but it addresses the multiple interconnections between systems affected by it from soils to trees, insects and pathogens, involving processes ranging from hydrological flow to plant species competition. Simulation results used in regional assessments address the various aspects of these issues separately to forecast responses to climate change, but the more we can combine these results using soils as the underlying framework of ecosystem functionality, the more robust our projections will become. The mosaic of soil characteristics across the landscape is a critical aspect of a vulnerability assessment because it is the key to water availability for not only growth but also regeneration of forests after disturbance, and good soil data is a scarce resource for modelers.

This study will provide detailed soil maps for the NPLCC, a soil vulnerability index, and a forecast map of where trees are likely to be most affected by changes in precipitation and temperature. We will then test the static MAPSS biogeography model and the MC1 dynamic global vegetation model (DGVM) against the soil vulnerability index and perform sensitivity analyses that will provide a basis for calculating the uncertainty due to soil-related inputs associated with projections of drought stress and forest dieback in the region. We will also compare the soil vulnerability index with results from climate envelope models to provide a more complete understanding of the strengths and weaknesses of the modeling approaches. All spatial datasets created in this project will be made publicly available on the web via Data Basin (databasin.org). Consequently, they will be usable by managers for assessment purposes as well as to research teams interested in testing the sensitivity of their tools to improved soil information.

Managers will be able to use soil vulnerability forecast maps together with results from vegetation models to better understand where and why trees may experience water stress and pest infestations, making them more vulnerable to fire risk. They will be better able to respond with mitigation strategies such as prescriptive fire, thinning, planting of more tolerant species or genotypes, or biochar application as the need they will perceive may be.

Objective:

This project will address three of the NPLCC objectives laid out in this RFP. It will produce decision support tools (data and model results) available on databasin.org for conservation evaluation and planning. It will test assumptions of model projections by comparing the results of different types of models that use a variety of soil inputs at different temporal and spatial scales. The project will produce spatial datasets that inventory soil characteristics, soil water resources, and trends in soil-vegetation dynamics as the climate changes.

Methods:

GIS analysis of existing soil data will be performed by Conservation Biology Institute GIS specialist and soil scientist Wendy Peterman. She has been studying the connections between soil characteristics in forest mortality and climate change in the southwestern USA (manuscript submitted for publication to Geoderma), the PNW Cascades, and the California Sierras. She has also provided soil vulnerability index maps for Wind Cave National Park. Her method uses SSURGO, STATSGO and Forest Service remote sensing data to connect soil characteristics to forest health in a decision tree analysis to create forecast maps of where soils are more vulnerable to changes in temperature and moisture regimes as the climate changes. Where needed, Peterman will perform field analysis and mapping of specific problem areas. Peterman will also be responsible for uploading all output datasets onto databasin.org.

Climate change scientist Dominique Bachelet will oversee the sensitivity analysis of the MAPSS biogeography model (Neilson 1995) and the MC1 dynamic global vegetation model (Bachelet et al. 2001) with regard to soils data. Both MAPSS and MC1 models use soil texture, mineral soil depth, percent rock fragment and bulk density data from SSURGO. Results from this study, using more detailed soils data at the landscape level, will be compared with results from the MC1 and MAPSS models using coarser soils data from an on-going project with the USDA Forest Service (domain of the study is Oregon and Washington), as well as results from the process-based species model 3PGS (Coops et al. 1998) from another on-going project Bachelet is co-investigating with Richard Waring, and from climate envelope models (Rehfeld et al. 2006) provided by her colleague Nick Crookston who has already interacted with Peterman to provide some of his results for Data Basin.

Geographic Extent:
The geographic extent of this study will include coastal areas of Alaska, British Columbia, Washington, Oregon and northern California encompassed by the NPLCC. MC1 and MAPSS results will focus on the Oregon and Washington portion of the domain. Waring and Crookston's results will include the entire NPLCC region.

Timeline of Schedules, Products and Outcomes

This is a 2-year project. Assuming a start in summer 2011, the workflow will proceed as follows:
1. Jul-Dec 2011: Integrated soil maps of all included areas at the 1:24,000 scale compiled, analyzed and updated with significant attributes.
2. Jul 2011-Jun 2012: 1) Statistical correlations of individual and combined soil characteristics and forest dieback or expansion, and reports of areas affected by each, 2) Initial forecast maps of

high, medium and low vulnerability areas based on soil characteristics, 3) Decision-tree analysis and further predictive maps based on soil vulnerability forecast maps.
3. Jan-Dec 2012: 1) Sensitivity analysis of MAPSS and MC1 models, 2) gathering of latest 3PG-S and envelope model results to compare with soil vulnerability forecast maps.

In terms of communicating the results, we plan to present results at two national meetings on the 2nd year of the project: the 97th ESA annual meeting, August 5 –10, 2012 in Portland OR, and the SSSA-ASA-CSA International Meeting, October 21-24, 2012 in Cincinnati OH.

	Jul-Dec 2011	Jan-Jun 2012	Jul-Dec 2012	Jan-Jun 2013
Products:				
Soils maps for NPLCC	XXXXXX	XX		
Correlation analysis between forest dieback/expansion and soil characteristics: vulnerability index		XXXXXX	XX	X
Sensitivity analysis of MAPSS		XXXXXX	X	X
Sensitivity analysis of MC1		XXXXXX	XXXX	X
Comparison of MAPSS, MC1, 3PGS, envelope models with soil vulnerability index maps		XXXXXX	XXXXXX	XX
Communication:				
Presentations at national meetings			X X	
Interim and final report to Fish and Wildlife; uploading in Data Basin		X		X
Manuscript preparation				XXXXXX

Final Products include:

1) Soil vulnerability forecast maps for the entire NPCC region,
2) Spatial datasets illustrating the results of running MC1 DGVM and MAPSS biogeography model with different soil inputs
3) Spatial datasets of MC1, MAPSS, 3PG-S, and envelope model results compared with soil vulnerability maps available on the web (databasin.org)
4) Documentation about each model approach and report on model performance and comparisons available on the web (databasin.org) with the associated datasets.
5) At least one manuscript to submit to a climate change-focus peer-reviewed journal, interim and final reports to Fish and Wildlife.

References

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Crimmins, S. M., S. Z. Debrowski, J. A. Greenberg, J. T. Abatzoglou, and A. R. Mynsberge. 2011. Changes in climatic water balance drive downhill shifts in plant species optimum elevations. Science 331: 324. DOI: 10.1126/science.1199040

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Mote, P. W., A. F. Hamlet, M. P. Clark, and D. P. Lettenmaier. 2005. Declining mountain snowpack in western North America. Bulletin of the American Meteorological Society 86: 35-49.

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Budget
Our budget includes salary support for Conservation Biology Institute employees Wendy Peterman (soils analysis, vulnerability index, uploading in Data Basin) and Dominique Bachelet (overall coordination, model testing, model result gathering).

It includes travel money for Ms Peterman to attend two national science meetings in 2012 ($3000) and some travel money to conduct field work.

ATTACHMENT 3 - COST PROPOSAL SAMPLE FORMAT

WENDY PETERMAN		Year 1 (7/1/11 - 6/30/12)		Year 2 (7/1/12- 6/30/13)		Proposal Number: CBI Match		Grand Total
Labor	Rate	Units	Total	Units	Total	Units	Total	
Lead Technical Individual - Bachelet	$65.45	110	$7,200	110	$7,200		$0	$14,400
Other Significant Technical Individual - by name			$0		$0		$0	$0
Labor Category #1-Peterman, Wendy	$40.52	500	$20,260	500	$20,260		$0	$40,520
Labor Category #2			$0		$0		$0	$0
Labor Category #3			$0		$0		$0	$0
TOTAL LABOR (*1)		**610**	**$27,460**	**610**	**$27,460**		**$0**	**$54,920**
Indirect Charge #1	0.00%		**$0**		**$0**		**$0**	**$0**
Subcontractors and co-performers								
All federal partners or subcontractors receiving greater than $10,000 require a separate cost sheet.								
Government Organization/Lab #1								**$0**
Organization Name (Subcontractor 1)								**$0**
Organization Name (Subcontractor 2)								**$0**
Organization Name								**$0**
Total Co-performer or Subcontractor			**$0**		**$0**		**$0**	**$0**
Travel:								
Domestic Travel			$4,812		$3,312			**$8,124**
Foreign Travel								**$0**
Total Travel			**$4,812**		**$3,312**		**$0**	**$8,124**
Other Direct Costs:								
Major Equipment								**$0**
Materials, Supplies and Consumables								**$0**
Publication Costs								**$0**
Other-Data Basin					$1,500		$16,129	**$17,629**
Total Other Direct Costs			**$0**		**$1,500**		**$16,129**	**$17,629**
Subtotal Cost			**$32,272**		**$32,272**		**$16,129**	**$80,673**
Indirect Charge #2 Indirect Rate including computer support	55.00%		$17,728		$17,728		$8,871	**$44,327**
Total Cost Excluding Fee			**$50,000**		**$50,000**		**$25,000**	**$125,000**
Fixed Fee @ X% (if applicable) - Excluding Equipment (*4)	0%		$0		$0		$0	**$0**
TOTAL PRICE			$50,000		$50,000		$25,000	$125,000

(*1) Total Labor - Hourly or salary	**610 labor hours including fringe benefits**
(*2) Indirect Charge #1 -	**n/a**
(*3) Indirect Charge #2 -	**Indirect cost rate including computer, network, software support**
(*4) Fixed Fee, if any	**n/a**

Disclaimer regarding Data Sharing

Public spatial datasets uploaded in databasin.org will be freely available for viewing, analyzing, and free downloading.

Ms Peterman's unpublished results will be uploaded as private in Data Basin, pending peer review, available on a per request basis, and made available to the general public after a peer reviewed manuscript describing the methods and results has been accepted for publication.

CONSERVATION BIOLOGY INSTITUTE

Wendy L. Peterman, M.S. — Curriculum Vitae

136 SW Washington Avenue, Suite 202

Corvallis, Oregon 97333

Wendy Peterman is a soil scientist with a background in GIS mapping and analysis of pedology, geomorphology and hydrology. At OSU, she contributed to the advancement of predictive mapping technology by developing a technique for predicting landtype association (EcoregionV) maps for the US Forest Service from existing vegetation, geology, landform and soil maps. Prior to that, she assisted in mapping the soils, geology and hydrology of the island of Cyprus. At Conservation Biology Institute, she is in charge of data management for the Data Basin (www.databasin.org) online tool, and conducts soils studies for conservation and management plans.

EDUCATION

M.S. Soil Science, Oregon State University, 2010.
Post-Baccaleaureate, Environmental Science: Applied Ecology and Natural Resource Management, 2009

SELECTED CONSERVATION PROJECT EXPERIENCE

Conservation Scientist. Produced rapid ecological assessments for the Colorado Plateau and the Sonoran Desert ecoregions for the conservation elements: Soil stability (in each region), biological soil crusts and pinyon pines. Designed conceptual and application models to create predictive maps of elements and change agents for management use.

Soil Scientist, Developed soil vulnerability map for Arizona, Utah, Colorado and New Mexico for use in forecasting pinyon pine mortality during prolonged drought. Developed soil vulnerability map for Wind Cave National Park climate change/vegetation change forecasting.

Data upload lead for Data Basin. Led dataset upload phase of databasin.org development. Managed and prioritized dataset preparation and upload requests from internal and external sources. Communicated with Data Basin users to provide technical support. Interfaced with software development team to overcome problems with data uploads. Researched correlations between soil physical properties and forest dieback in drought-affected forests of the southwestern USA.

Graduate Research Assistant, OSU. Produced 1:100,000 Landtype Association (LTA) maps and tables for resource management in the Fremont, Deschutes and Ochoco National Forests. Planned and performed all field work associated with groundtruthing maps.

Developed mathematical models for calculating average annual rainfall of an area based on Pleistocene stream morphology, cross-sectional area, current streamflow and rainfall data for the government of Cyprus.

Performed Hypsometric Analysis of the drainages on the northern and southern faces of the Troodos mountains in Cyprus to determine relative uplift activity versus erosion.

GIS specialist, OSU. Developed and analyzed DEM's and remote sensing data for geological and hydrological characteristics. Digitized surficial geology, soils and 4 m contours for eastern Oregon and the island of Cyprus.

SELECTED PUBLICATIONS

Peterman, W.L., 2011. Forecasting pinyon pine vulnerability to climate change using available soil characteristics. Submitted to Geoderma.

Peterman, W.L., 2010. Predictive mapping of landtype association maps in three Oregon national forests. Masters thesis, Oregon State University. http://ir.library.oregonstate.edu/xmlui/handle/1957/16399

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Dominique Bachelet

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Education

Colorado State University, Botany and Plant Pathology, 1983, Ph.D.
Université de Paris XI (France), Plant Ecology, 1979, DEA.
Université de Lille I (France), Plant Biology, 1978, MS.

Professional experience

Senior Climate Change scientist, Conservation Biology Institute, 2009-current
Associate Professor, Senior Research, Dept of Bioengineering, Oregon State University, 1999-present.
Director of Climate Change Science, The Nature Conservancy, 2007-2008
Assistant Professor, Dept of Bioresource Engineering, Oregon State University, 1989-1999
Adjunct Assistant Professor, Dept of Natural Resources, University of New Hampshire, 1995-6
Visiting scientist, Centre National de la Recherche Scientifique, CESBIO Toulouse, 1994-1995.
Research Scientist, ManTech Envir. Technology Inc., US-EPA Envir. Res. Lab., 1988-1994.
Research Specialist, New Mexico State University, 1986-1988.
Postdoctorate Research Ass., Soil and Envir. Sc. Dept, U. of California, Riverside, 1984-1986.

Recent publications

Bachelet, D., B.R. Johnson, S.D. Bridgham, P.V. Dunn, H.E. Anderson, B.M. Rogers. 2011. Climate change impacts on Western Pacific Northwest prairies and savannas. Accepted Northwest Science Journal.

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Bachelet D. and D. Price. 2008. DGVM responses to the latest IPCC future climate scenarios. Global and Planetary Change. 64 (1-2):1-2.

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Daly, C., D. Bachelet, J.M. Lenihan and R.P. Neilson. 2000. Dynamic simulation of tree-grass interactions for global change studies. Ecological Applications 10(2):449-469.

List of collaborators:

C. Allen (USGS New Mexico), P. Ciais (CEA, France), M. Cross (WCS Bozeman), C. Daly (Oregon State U.), M. Hemstrom (USDA Forest Service PNW), B. Kerns (USDA Forest Service PNW), J.M. Lenihan (USDA Forest Service PNW), R.P. Neilson (USDA Forest Service PNW), D. Ojima (Heinz Center), W.J. Parton (Colorado State U.), R. Shaw (TNC CA), K. Thonicke (PIK, Germany), R. Waring (2010), J. Wiens (PRBO, CA).

Past students:

Marilynn Bartels (M.S., Botany and Plant Pathology, 2000), Michael Cairns (Ph. D., Botany and Plant Pathology, abandoned 2001), David Conklin (Ph. D., Biological and Ecological Engineering 2009), Lance George (M.S., Forest Science), Katherine Jacobs (M.S., Forest Science, 2002), Jonathan Kehmeier (M.S., Bioengineering, 2000), France Lamy (Ph. D., Bioengineering, replaced June 2002), Jennifer Larsen (M.S., Geography, 2005), Julian Licata (M.S., Forest Science, 2004; Ph. D., Forest Science, 2007), Patrick McQuarrie (Ph. D., Geosciences), Rozi Mohammed (M.S., Forest Science, 1999), Kristen Overturf (M.S., BioResource Engineering, 1999), Debbie Reusser (Ph. D., Geosciences 2010), Daniel Sarr (Ph. D., Forest Science, 2004), Carla Stevens (M.S., Biological and Ecological Engineering).

Past postdocs and interns:

Christophe Cassen (ENGREF, France – summer 2007), David Conklin (Postdoctoral scholar, Biological and Ecological Engineering, 2009-2010), Yutaka Hagimoto (Postdoctoral fellow, Biological and Ecological Engineering - 2004-2008), Michael Tolg (Germany, 1993).

Current graduate students:

Charles Hillyer (Ph. D., Biological and Ecological Engineering), Tara Hudiburg (Ph.D. Forest Science

Letters of Support from Potential Users

1. Dr. Peter Beedlow, EPA

From: Beedlow.Peter@epamail.epa.gov

Date: Fri, Apr 29, 2011 at 4:52 PM

Subject: Re: Fwd: letter of support?

To: Wendy Peterman <wendy@consbio.org>

Wendy-

The role of soils in affecting the vulnerability of forest ecosystems to Global Climate change is much needed area of research. While readily available, SSURGO and STATSGO data are of limited use in vulnerability analyses in and of themselves. Quantifying the significant soil characteristics in relation to forest growth and dieback will provide much needed information for assessing the impacts of climate change on forests. The approach proposed seems logical and doable within the allotted time frame. the proposal is worthy of funding.

Sincerely,

Peter A. Beedlow, PhD

US Environmental Protection Agency

Corvallis, OR

office: 541-754-4634

cell: 541-840-2549

2. Dr Peter Homann, prof. of Environmental Sciences from Western Washington University (see below)

3. Nikola Smith, associate ecologist with USDA Forest Service (see below)

4. Glenn Howe, ass. prof. of Forest Genetics from Oregon State University

WESTERN WASHINGTON UNIVERSITY

HUXLEY COLLEGE OF THE ENVIRONMENT

Department of Environmental Sciences

Bellingham WA 98225-9181

May 2, 2011

e: ini ue B ele en y ee n's 2011 N LCC l

To: NPLCC Science Advisory Team

The integration of soils information into assessments of climatic-driven vegetation changes is a critical step to producing refined forecasts of climate impacts. Until quite recently, consideration of the interaction between soils and climate as they influence regional vegetation dynamics has been very limited. The proposal by Dominique Bachelet and Wendy Peterman to conduct such an evaluation across the Pacific Northwest region is very appropriate, because of the substantial variability in soil characteristics across this region (Homann et al., 2005).

Should pedon (soil pit) information about Pacific Northwest soils be required, I can provide that across spatial scales from experimental units (Homann et al., 2008) to the region (Homann et al., 2007). Information about alternation of soils by wildfire is also available (Homann et al., 2011).

Respectfully,

Peter Homann

Peter Homann
Professor of Environmental Sciences

References

Homann, P.S., B.T. Bormann, R.L. Darbyshire, B.A. Morrissette. 2011. Forest soil C and N Losses associated with wildfire and prescribed fire. Soil Science Society of America Journal. *In e .*

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File Code: 1300 **Date:** April 29, 2011

Route To: North Pacific Landscape Conservation Cooperative

Subject: Letter of Support for Wendy Peterman

To: North Pacific Landscape Conservation Cooperative

I attended the Western Conifer and Climate Change Consortium in Portland earlier this year where I saw a presentation on Ms. Peterman's research on integrating soil properties with climate change vegetation models. I thought it was a very timely and poignant presentation, given the current lack of soils data in vegetation modeling. My colleague, Karen Bennett has recently been emphasizing the importance of including soils data in climate and vegetation models. Soil characteristics are significant factors in a landscape's hydrology, chemistry and fertility. The addition of detailed, site specific soils data to these models can help us better understand forest cover migration, and carbon/nitrogen cycling as the climate changes. Ms. Peterman's research could help inform our management of national forests in the Pacific Northwest Region, and support the implementation of our climate change strategy.

Sincerely,

NIKOLA SMITH
Associate Ecologist

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May 3, 2011

Dr. Dominique Bachelet
Conservation Biology Institute
136 SW Washington Avenue, Suite 202
Corvallis, OR 97333

Dear Dominique:

I am happy to support your proposal to the North Pacific Landscape Conservation Cooperative. Your proposed research is particularly relevant because climate change is expected to increase drought stress throughout much of western North America. Knowledge of location-specific effects through your soil vulnerability index and map will be valuable for identifying vulnerable forests, thereby allowing managers to implement conservations efforts and other management practices that will help ameliorate the adverse effects of climate change. The availability of improved decision support tools through databasin.org will be particularly helpful to land managers.

Cordially,

Glenn Howe

Glenn Howe
Associate Professor of forest genetics